MARAIS DES CYGNES RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody Assessment Unit: Rock Creek Lake
Water Quality Impairment: Eutrophication

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Marmaton River **County:** Bourbon

HUC 8: 10290104 **HUC 11** (HUC 14): **010** (080)

Drainage Area: Approximately 15.75 square miles
10 square miles drain first to Ft. Scott Lake
5.75 square miles drain directly into Rock Creek Lake

Conservation Pool: Area = 75 acres
Watershed/Lake Ratio: 134:1
Maximum Depth = 5 meters
Mean Depth = 2.0 meters
Estimated Retention Time = 0.07 years

Designated Uses: Primary Contact Recreation (B); Expected Aquatic Life Support; Domestic Water Supply; Food Procurement; Industrial Water Supply; Irrigation Use; Livestock Watering Use; Groundwater Recharge

2004 303(d) Listing: Water Quality Limited Lakes; Eutrophication

Impaired Use: All uses are threatened to a degree by eutrophication

Water Quality Standard: Nutrients – Narrative: The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life (KAR 28-16-16-28e(c)(2)(A))

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (KAR 28-16-28e(c)(7)(A)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Eutrophication: Fully Eutrophic, Trophic State Index Avg.= 57.0

The Trophic State Index (TSI) is derived from the chlorophyll *a* concentration (Chla). Trophic state assessments of potential algal productivity were made based on chlorophyll *a* concentrations, nutrient levels and values of the Carlson Trophic State Index (TSI). Generally, some degree of eutrophic conditions is seen with chlorophyll *a* concentrations over 12 µg/L and hypereutrophy occurs at levels over 30 µg/L. The Carlson TSI derives from the chlorophyll *a* concentrations and scales the trophic state as follows:

1. Oligotrophic TSI: < 40
2. Mesotrophic TSI: 40 – 49.99
3. Slightly Eutrophic TSI: 50 – 54.99
4. Fully Eutrophic TSI: 55- 59.99
5. Very Eutrophic TSI: 60 – 63.99
6. Hypereutrophic TSI: ≥ 64

TSI (chla) = 9.81*ln(chla)+30.6 (chla in ppb)

Monitoring Sites: Station LM045201in Rock Creek Lake (Figure 1).

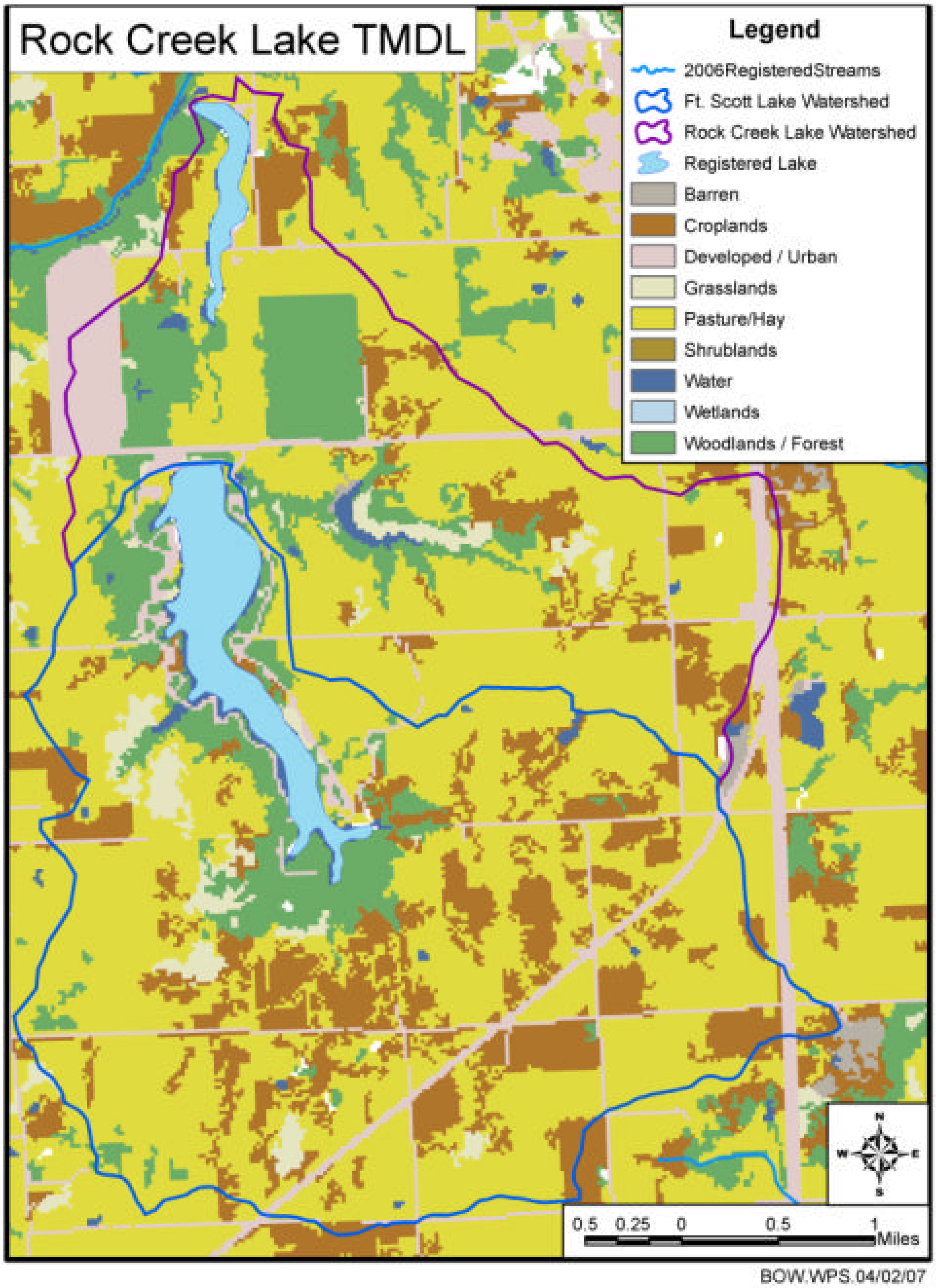


Figure 1. Rock Creek TMDL Reference Map. The larger lake in the southern portion of the drainage is Ft. Scott Lake, the smaller lake in the northern part of the drainage is Rock Creek Lake. No registered streams drain into either lake.

Period of Record Used: Three surveys conducted by KDHE in calendar years 1986, 1990, and 2004.

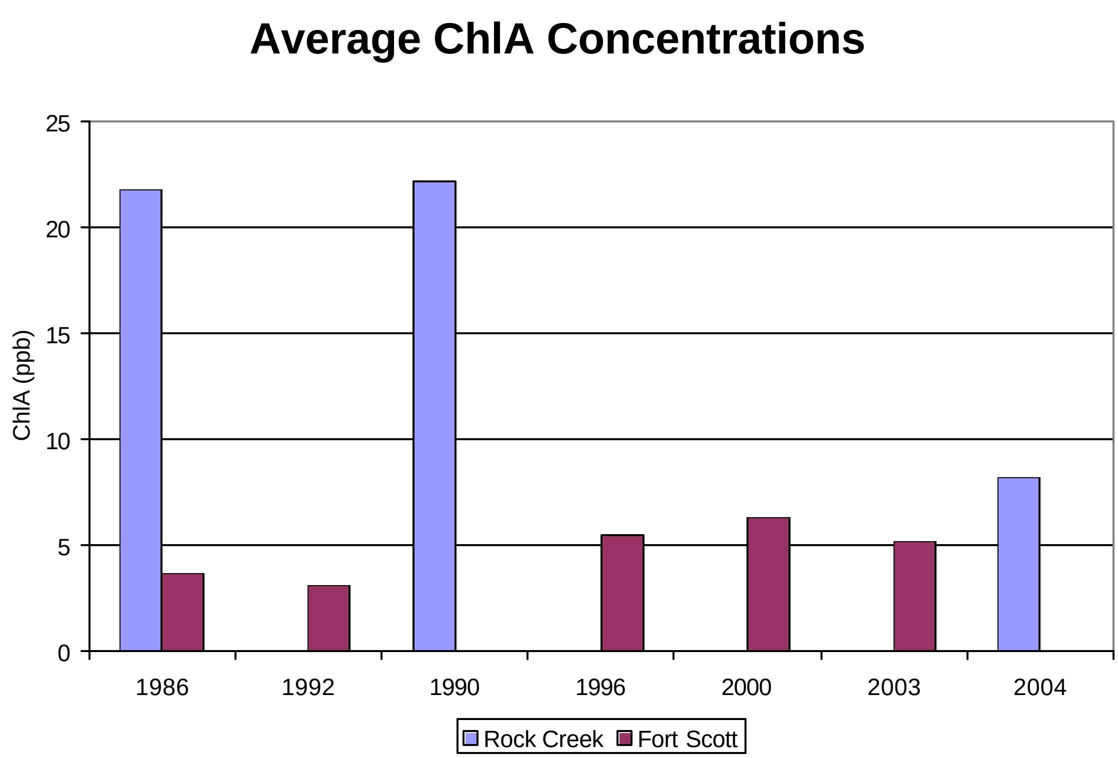
Current Condition: The overall Chlorophyll *a* concentrations in Rock Creek Lake averaged more than 20 ppb during the two older samples. The most recent sample averaged 8.2 ppb ChlA.

The ratio of total nitrogen and total phosphorus is a common ratio utilized to determine which of these nutrients is most likely limiting plant growth in Kansas aquatic ecosystems (Dzialowski et al., 2005). Typically, lakes that are N limited have a water column TN:TP ratio < 10 (mass); lakes that are co-limited by N and P have a TN:TP ratio between 10 and 17; and lakes that are P limited have a water column TN:TP ratio > 17 (Smith, 1998). The total phosphorus concentrations for samples obtained at 0.5 meters or less average 64.3 ppb over the period of record. Total nitrogen concentrations have average 702 ppb (0.702 mg/l). Average TN/TP ratio has been 13.2 suggesting that nitrogen and phosphorus co-limit algal productivity in this lake.

Secchi depth was recorded in 2004 (0.83m). Light may be limiting under some conditions.

Year	Chl *a* (ppb)	TP (ppb)	TN (mg/L)	TN:TP Ratio
1986 (0.5 m)	21.75	85	NA	NA
1990 (0.5m)	22.2	50	NA	NA
2004 (0.5m)	8.2	53	0.713	13.2

(Table 1- Total Phosphorus and Total Nitrogen annual averages for Rock Creek Lake at 0.5 meters.**)**



(**Figure 2**- Chlorophyll *a* averages for Rock Creek Lake sampling events. Ft. Scott Lake include as regional reference.**)**

Interim Endpoints of Water Quality (Implied Load Capacity) at Pony Creek Lake:

This TMDL will correspond with the state goal of achieving a chlorophyll *a* long-term concentration average of 10 ppb or less. The desired endpoint will maintain the trophic condition of the lake at or below its current summer chlorophyll *a* concentration (below 10 µg/L) since the lake serves as a Public Water Supply and is designated for Primary Contact Recreation.

3. SOURCE INVENTORY AND ASSESSMENT

General Background: Rock Creek Lake is directly downstream from Ft. Scott Lake. Ft. Scott Lake has not been identified as suffering impairment of water quality. The total watershed feeding Rock Creek Lake is 15.75 sq. miles, but only about one third of the watershed feeds Rock Creek Lake without first traveling through Ft. Scott Lake. Ft. Scott Lake discharges epilimnetic water through an overflowing pipe design, with a spillway for larger volumes during major runoff events. The difference in the two lake's status may reflect the small size and depth of Rock Creek Lake, allowing for relatively greater surface area to volume ratio at Rock Creek, so that internal loading from deposited sediment plays a larger role. The lack of impairment at Ft. Scott Lake suggests that much of the water entering Rock Creek Lake meets water quality criteria, and that any impairment in the lake will need to address both land management in the watershed and internal nutrient cycling.

Land Use: Rock Creek Lake is fed by streams which do not flow regularly and are not on the Kansas Surface Water Register. The City of Fort Scott utilizes Rock Creek Lake as one of their sources for their Public Water Supply. The population of Fort Scott according to the 2000 U.S. Census is 8,297. Projected population estimates provided by the Kansas Water Office for Ft. Scott indicate a slight growth trend through 2040 to nearly 9,500 people.

Rock Creek Lake has a moderate potential for nonpoint source pollutants. The major source of phosphorus within the Rock Creek Lake is runoff from agricultural lands where grazing livestock have access to the stream and to a lesser extent the limited cropland in the watershed. Land use coverage analysis indicates that 59% of the watershed is in permanent grass, 16.5% in cropland, 12.5% in forest, 6.3% in developed land, and 5% in open water (**Figure 1**).

CNET modeling was used to estimate total phosphorus concentrations necessary to generate the conditions observed in the 1986 and 1990 samples. Input files are included in the Appendix. These models suggest that during those years an average incoming total phosphorus concentration of 250 µg/l would have generated the conditions observed in the lake. Models developed by KDHE personnel were used to estimate the total nitrogen concentrations corresponding to the conditions observed during these two years. They suggest that 1100 µg/l total nitrogen corresponds to the conditions observed in the lake. They also suggest that 900 µg/l total nitrogen will allow the desired condition in this lake. Based on total load estimates, this corresponds to a reduction from 60,000 lbs per year total nitrogen to a 49,090 lbs per year load (900/1100 * 60,000).

Animal waste adds to the phosphorus load going into Rock Creek Lake. Animal waste from confined animal feeding operations does not add to the nitrogen and phosphorus load going into Rock Creek Lake. There are no active permitted animal feeding operations in the watershed.

Some fertilizer use and on-site waste systems may be associated with residential development around Ft. Scott Lake, but no housing exists adjacent to Rock Creek Lake. Faulty septic systems within the drainage basin of Rock Creek may contribute nutrients, particularly nitrogen, to the lake.

Contributing Runoff: The watershed of Rock Creek Lake has a mean soil permeability value of 0.38 inches/hour, ranging from as high as 1.29 inches/hour to as low as 0.02 inches/hour, according to the Kansas Mean Soil Permeability database from the Kansas Geological Survey. Sixty percent of the watershed has greater than 0.75 inches/hour infiltration rates. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watersheds' soil profiles become saturated, excess overland flow is produced.

Background: Leaf litter and wastes derived from natural wildlife may add to the nutrient load. Atmospheric and geological formations (i.e. soil and bedrock) may also contribute to the nutrient loads.

4. ALLOCATION OF POLLUTANT LOAD RESPONSIBILITY

Phosphorus and nitrogen are predominately co-limiting nutrients in Pony Creek Lake and allocated under this TMDL. The general inventory of sources within the drainage area indicates load reductions should be focused on nonpoint source runoff contributions attributed to livestock facilities and fertilizer applicators.

Point Sources: A current Wasteload Allocation of zero is established by this TMDL because of the lack of discharging NPDES point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired lake, the current Wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers. All livestock facilities will have a wasteload allocation of zero, reflective of their nondischarging status.

Nonpoint Sources: The assessment suggests that cropland, animal waste, and background erosion contribute to the state of the lake. Load reductions should be focused on nonpoint source runoff contributions attributed to the livestock grazers and fertilizer applicators within the watershed. Water quality violations are partially due to leaf litter and geology. This TMDL allocates total phosphorus and total nitrogen to maintain the desired concentrations of Chlorophyll A. The allocations are based on inflow concentrations combined with internal loading estimates. CNET models were used to estimate TP and models developed by KDHE personnel were used to estimate TN. CNET models suggest that an annual average stream inflow concentration of 140 µg/l is necessary to maintain a ChlA concentration below 10 ppb. This corresponds to a reduction of 110 µg/l from the conditions observed during the 1986 and 1990 samples. CNET suggests that this will correspond to an in-lake concentration of 30 µg/l, a level broadly correlated with lakes that meet water quality criteria. Models developed by KDHE personnel were used to estimate the total nitrogen concentrations necessary to maintain a ChlA concentration below 10 ppb. These models suggest that 900 µg/l concentration, a reduction of 200 µg/l below the 1986 and 1990 samples is required. The required daily load allocation is calculated in Appendix A and is 37 lbs/day of total phosphorus and 360 lbs/day of total nitrogen. The inflow concentrations are based on a total nitrogen goal of 0.9 mg/l and total phosphorus of 0.075 mg/l.

Percent Flow Exceedence	90%	75%	50%	25%	10%
Rock Creek Estimated Flow Calculations (cfs)	0.03	0.19	2.04	7.65	23.20
TN @ 0.9mg/l (lbs/day)	0.14	0.94	9.92	37.19	112.77
TP @ 0.075 mg/l (lbs/day)	0.01	0.08	0.83	3.10	9.40

(Table 2- Daily load allocations for inflows of Rock Creek Lake. Flow estimates are derived from watershed area ratios and USGS estimated flow in a nearby gaged stream.**)**

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of variable annual total phosphorus loads and the chlorophyll *a* endpoint. Therefore, the margin of safety is implicit in the 10 ppb Chlorophyll A criteria, which is 17% less than the current KDHE guidance on primary contact recreational waters of 12 ppb Chlorophyll A. The margin of safety is further expressed by the inclusion of an explicit 10% margin of safety in the calculation of nutrient loads corresponding to desired conditions in the lake. These two criteria should ensure that the lake meets it's designated uses.

State Water Plan Implementation Priority: Because the Rock Creek Lake is used for public drinking water and Primary Contact Recreation, this TMDL will be a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Marmaton (HUC 8 10290104) with a priority ranking of 17 (High Priority for restoration).

5. IMPLEMENTATION

Desired Implementation Activities:
There is potential that agricultural best management practices will improve the condition of Rock Creek Lake. Some of the recommended agricultural practices are as follows:

1. Implement soil sampling to recommend appropriate fertilizer applications on cropland.
2. Maintain conservation tillage and contour farming to minimize cropland erosion.
3. Install grass buffer strips along streams and drainage channels in the watershed.
4. Reduce activities within riparian areas.
5. Implement nutrient management plans to manage manure land applications and runoff potential.

Implementation Programs Guidance:

Fisheries Management – KDWP

a. Assist evaluation in-lake or near-lake potential sources of nutrients to lake.
b. Advise county on applicable lake management techniques, which may reduce nutrient loading and cycling in lake.

Nonpoint Source Pollution Technical Assistance- KDHE

a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.
c. Provide technical assistance on nutrient management for livestock management in the watershed.
d. Guide federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority watersheds and stream segments within those subbasins identified by this TMDL.
e. Incorporate lake protection and restoration in the plan for the Ft. Scott Lake WRAPS.

Water Resource Cost Share and Nonpoint Source Pollution Control Programs – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Apply conservation farming practices and/or erosion control structures, including no-till, terraces and contours, sediment control basins, and constructed wetlands.
c. Provide sediment control practices to minimize erosion and sediment and nutrient transport.
d. Re-evaluate nonpoint source pollution control methods.

Riparian Protection Program – SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects.
c. Promote lake construction to assimilate nutrient loadings.

Buffer Initiative Program – SCC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

CRP Enrollment- NRCS

a. Enroll highly erodable lands in the conservation reserve program.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Educate livestock producers on livestock waste management and manure applications and nutrient management planning.
c. Provide technical assistance on livestock waste management systems and nutrient management planning.
d. Provide technical assistance on buffer strip design and minimizing cropland runoff.
e. Encourage annual soil testing to determine capacity of field to hold phosphorus.
f. Continue to educate residents, landowners, and watershed stakeholders about nonpoint source pollution.

Time Frame for Implementation: Implementation of targeted best management practices should occur before 2012. During 2007-2015 monitoring of in lake conditions shall continue.

Targeted Participants: Primary participants for implementation will be the livestock producers and agricultural producers within the drainage of the lake. Initial work in 2008 should include local assessments by conservation district personnel and county extension agents to survey, locate, and assess the following within the lake drainage area:

1. Total row crop acreage
2. Cultivation alongside lake
3. Livestock use of riparian areas
4. Fields with manure applications

Milestone for 2012: The year 2012 marks the next cycle of 303(d) activities in the Marais des Cygnes Basin. At that point in time, sampled data from Rock Creek Lake should indicate evidence of continued low lake concentrations of total phosphorus, total nitrogen and chlorophyll *a,* similar to those observed in the 2004 survey.

Delivery Agents: The primary delivery agents for program participation will be the Bourbon County Conservation District for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension. The Kansas Department of Health and Environment shall continue to monitor lake conditions.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollutants and to assure allocations of pollutants to point and non-point sources can be attained.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected Watershed Restoration and Protection Strategies.

6. K.S.A 82a-1601, et seq. creates the Multipurpose Small Lakes Program to protect smaller lakes that serve multiple functions, including adequate land treatment measures that will provide protection from pollution and siltation.

7. The *Kansas Water Plan* and the Missouri Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a **High Priority** consideration.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming and proper livestock management within the watershed cited in this TMDL.

6. MONITORING

KDHE will continue sampling Rock Creek Lake once every four years in order to assess the impairment that drives this TMDL. Based on the sampling results, the impairment status of the lake will be evaluated in 2012. Should the impairment status be verified, the desired endpoints under this TMDL may be refined and call for more intensive sampling conducted over the period 2013-2015 to assess progress in this TMDL's implementation.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Marais des Cygnes Basin have been held since 2001. An active Internet Web site was established at www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs in the Marais des Cygnes Basin and these specific TMDLs.

Public Hearing: A Public Hearing on these Marais des Cygnes Basin TMDLs will be held in Ft. Scott on May 31, 2007.

Basin Advisory Committee: The Marais des Cygnes Basin Advisory Committee met to discuss these TMDLs on June 22, 2006 in Pomona, November 29, 2006 in Williamsburg, December 18, 2006 in Ft. Scott, January 30, 2007 in Ottawa, March 13, 2007 in Ft. Scott and May 17, 2007 in Ottawa.

Milestone Evaluation: In 2012, evaluation will be made as to implementation of management practices to minimize the non-point source runoff contributing to this impairment. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2012.

Consideration for 303d Delisting: The river/lake will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2008-2015. Therefore, the decision for delisting will come about in the preparation of the 2016 303d list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2007 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2008-2015.

Revised July 17, 2007

Appendix A– Conversion to Daily Loads as Regulated by EPA Region VII

The TMDL has estimated annual average loads for TN and TP that if achieved should meet the water quality targets. A recent court decision often referred to as the "Anacostia decision" has dictated that TMDLs include a "daily" load (Friend of the Earth, Inc v. EPA, et al.).

Expressing this TMDL in daily time steps could be misleading to imply a daily response to a daily load. It is important to recognize that the growing season mean chlorophyll *a* is affected by many factors such as: internal lake nutrient loading, water residence time, wind action and the interaction between light penetration, nutrients, sediment load and algal response.

To translate long term averages to maximum daily load values, EPA Region 7 has suggested the approach describe in the Technical Support Document for Water Quality Based Toxics Control (EPA/505/2-90-001)(TSD).

Maximum Daily Load (MDL) = (Long-Term Average Load) * $e^{[Zs - 0.5s^2]}$

where $s^2 = \ln\left(CV^2 + 1\right)$

CV = Coefficient of variation = Standard Deviation / Mean

Z = 2.326 for 99^{th} percentile probability basis

LTA= Long Term Average

LA= Load Allocation

MOS= Margin of Safety

Parameter	LTA- lbs/year	CV	$e^{[Zd-0.5d^2]}$	MDL- lbs/day	LA- lbs/day	MOS (10%)- lbs/day
TP	2064	0.5	2.683671435	21.05763011	18.9518671	2.105763011
TN	49,090	0.5	2.683671435	360.9354267	324.8418841	36.09354267

Maximum Daily Load Calculation

Maximum Daily Load = (Long-Term Average Load) * e $^{[Zs - 0.5s^2]}$

where $s^2 = \ln\left(CV^2 + 1\right)$
CV = Coefficient of variation (0.5)
Z = 2.326 for 99th percentile probability basis

Annual TN Load = 49,090 lbs/yr

Maximum Daily TN Load = [(49,090 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 324 lbs/day

Annual TP Load = 2864 lbs/yr

Maximum Daily TP Load = [(2864 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.412)-0.5*(0.412)^2]}$
= 19 lbs/day

Margin of Safety (MOS) for Daily Load

Annual TN MOS = 4,900 lbs/yr

Daily TN MOS = [(4090 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.472)-0.5*(0.472)^2]}$
= 36 lbs/day

Annual TP MOS = 769 lbs/yr

Daily TP MOS = [(769 lbs/yr)/(365 days/yr)]*e $^{[2.326*(0.412)-0.5*(0.412)^2]}$
= 2.1 lbs/day

Source- *Technical Support Document for Water Quality-based Toxics Control (EPA/505/2-90-001)*

Appendix B- CNET model parameters

RESERVOIR EUTROPHICATION MODELING WORKSHEET TITLE -> **Rock Creek Lake**

Based on CNET.WK1 VERSION 1.0

VARIABLE	UNITS	Current	LC
WATERSHED CHARACTERISTICS...		Latitude	37
Drainage Area	km2	37.4	37.4
Precipitation	m/yr	1.04	1.04
Evaporation	m/yr	1.2	1.2
Unit Runoff	m/yr	0.246	0.246
Stream Total P Conc.	ppb	250	140
Stream Ortho P Conc.	ppb	0	0
Atmospheric Total P Load	kg/km2-yr	46	46
Atmospheric Ortho P Load	kg/km2-yr	0	0
POINT SOURCE CHARACTERISTICS...			
Flow	hm3/yr	0	0.0
Total P Conc	ppb	0	0.0
Ortho P Conc	ppb	0	0
RESERVOIR CHARACTERISTICS...			
Surface Area	km2	0.303	0.303
Max Depth	m	5	5
Mean Depth	m	2	2
Non-Algal Turbidity	1/m	0.65	0.75
Mean Depth of Mixed Layer	m	2	2
Mean Depth of Hypolimnion	m	0.73	0.73
Observed Phosphorus	ppb	64	30.0
Observed Chl-a	ppb	22	10.0
Observed Secchi	meters	0.83	1.00
MODEL PARAMETERS...			
BATHTUB Total P Model Number	(1-8)	5	5
BATHTUB Total P Model Name		VOLLENV	
BATHTUB Chl-a Model Number	(2,4,5)	5	5
BATHTUB Chl-a Model Name		JONES	
Beta = 1/S vs. C Slope	m2/mg	0.054765	0.1

VARIABLE	UNITS	Current	LC
AVAILABLE P BALANCE...			
Precipitation Load	kg/yr	7	7
NonPoint Load	kg/yr	529	296
Point Load	kg/yr	0	0
Total Load	kg/yr	536	303
Sedimentation	kg/yr	110	62
Outflow	kg/yr	426	241
PREDICTION SUMMARY...			
P Retention Coefficient	-	0.205	0.205
Mean Phosphorus	ppb	46.6	26.4
Mean Chlorophyll-a	ppb	22.1	9.6
Algal Nuisance Frequency	%	98.2	38.7
Mean Secchi Depth	meters	0.54	0.58
Hypol. Oxygen Depletion A	mg/m2-d	1127.8	744.1
Hypol. Oxygen Depletion V	mg/m3-d	1545.0	1019.3
Organic Nitrogen	ppb	709.4	432.6
Non Ortho Phosphorus	ppb	50.6	30.8
Chl-a x Secchi	mg/m2	11.9	5.6
Principal Component 1	-	2.97	2.55
Principal Component 2	-	0.83	0.61
	Observed	Pred	Target
Carlson TSI P	64.2	59.6	51.4
Carlson TSI Chl-a	60.9	61.0	52.8
Carlson TSI Secchi	62.7	68.9	67.7
OBSERVED / PREDICTED RATIOS...			
Phosphorus		1.37	1.14
Chlorophyll-a		1.00	1.04
Secchi		1.54	1.71
OBSERVED / PREDICTED T-STATISTICS...			

VARIABLE	UNITS	Current	LC
RESPONSE CALCULATIONS...			
Reservoir Volume	hm3	0.606	0.606
Residence Time	yrs	0.0662	0.0662
Overflow Rate	m/yr	30.2	30.2
Total P Availability Factor		1	1
Ortho P Availability Factor		0	0
Inflow Ortho P/Total P		0.000	0.000
Inflow P Conc	ppb	58.6	33.1
P Reaction Rate - Mods 1 & 8		0.5	0.3
P Reaction Rate - Model 2		#DIV/0!	#DIV/0!
P Reaction Rate - Model 3		0.4	0.2
1-Rp Model 1 - Avail P		0.746	0.824
1-Rp Model 2 - Decay Rate		#DIV/0!	#DIV/0!
1-Rp Model 3 - 2nd Order Fixed		0.770	0.844
1-Rp Model 4 - Canfield & Bachman		0.715	0.778
1-Rp Model 5 - Vollenweider 1976		0.795	0.795
1-Rp Model 6 - First Order Decay		0.938	0.938
1-Rp Model 7 - First Order Setting		0.968	0.968
1-Rp Model 8 - 2nd Order Tp Only		0.746	0.824
1-Rp - Used		0.795	0.795
Reservoir P Conc	ppb	46.6	26.4
Gp		0.507	0.507
Bp	ppb	39.5	18.1
Chla vs. P, Turb, Flushing	2	14.2	6.8
Chla vs. P Linear	4	13.0	7.4
Chla vs. P 1.46	5	22.1	9.6
Chla Used	ppb	22.1	9.6
ml - Nuisance Freq Calc.		3.0	2.2
z		-2.088	0.288

P Decay Calibration (normally =1)		1	1
Chlorophyll-a Calib (normally = 1)		1	1
Chla Temporal Coef. of Var.		0.35	0.35
Chla Nuisance Criterion	ppb	10	10

Phosphorus	1.17	0.48	v	0.045	0.383
Chlorophyll-a	-0.01	0.15	w	0.590	0.913
Secchi	1.60	1.98	x	0.018	0.387

WATER BALANCE...

Precipitation Flow	hm3/yr	0.32	0.32
NonPoint Flow	hm3/yr	9.20	9.20
Point Flow	hm3/yr	0.00	0.00
Total Inflow	hm3/yr	9.52	9.52
Evaporation	hm3/yr	0.36	0.36
Outflow	hm3/yr	9.15	9.15

ORTHO P LOADS...

				OrP %			
Precipitation	kg/yr	0	0	0.5	0%	14	14
NonPoint	kg/yr	0	0	0.23	0%	2300	1288
Point	kg/yr	0	0	0.8	0%	0	0
Total	kg/yr	0	0			2314	1302
Total	#/year	0	0			5091	2864

Appendix C: KDHE Nitrogen models

Acres of Landuse			Nitrogen Loading Coefficients			Nitrogen Annual Loads		
			Low	Mean	High	Low	Mean	High
			kgN/ac/yr	kgN/ac/yr	kgN/ac/yr	kgN/yr	kgN/yr	kgN/yr
Cropland	1678		1.4325	2.865	5.73	2403.735	4807.47	9614.94
Grassland	5980		0.7	1.4	2.8	4186	8372	16744
Urban	662		1.9185	3.837	7.674	1270.047	2540.094	5080.188
Feedlot (Barnyards)	0		17.604	35.208	70.416	0	0	0
Woodland	1270		0.3945	0.789	1.578	501.015	1002.03	2004.06
Lake (atmospheric)	507		10.488	20.976	41.952	5317.416	10634.832	21269.664
Total	9590	acres						
				Effective N-Load		12006.05	24012.11	48024.21
				Total N-Load		13678.21	27356.43	54712.85
		Current Condition		Total N-Load	lb/yr		60309.97676	

Regression Statistics

Multiple R	0.830694423	
R Square	0.690053224	TP+TN/Chl-a Data for Non Blue-Green Data
Adjusted R Square	0.685013439	
Standard Error	0.273021305	
Observations	126	

Analysis of Variance

	df	***Sum of Squares***	***Mean Square***	***F***	***Significance F***
Regression	2	20.41238042	10.20619021	136.9212	#VALUE!
Residual	123	9.16849786	0.074540633		
Total	125	29.58087828			

	Coefficients	***Standard Error***	***t Statistic***	***P-value***	***Lower 95.00***	***Upper 95.00***
Intercept	-0.742250583	0.228824959	-3.24374835	#VALUE!	-1.195195552	-0.28930561
x1	0.890424589	0.067593744	13.17318057	#VALUE!	0.75662692	1.024222258
x2	0.136484215	0.093052528	1.466743765	#VALUE!	-0.047707556	0.320675986

If TP =	30	ppb, Then Chl-a =	9.47	ppb most likely
and TN =	900	ppb	0.60	ppb lower 95th %ile
			148.23	ppb upper 95th %ile